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USE AND BENEFITS OF PRESSURE RECORDING GAGES

By J. M. DIVEN

Recording gages for keeping a permanent record of steam and water pressures and vacuum have been used by water works for many years. In 1891 Mr. Charles A. Hague, in his introduction of his valuable paper entitled "Value of Pressure Records in Connection with Water Works," said that we should know what is going on inside of steam and water pipes, just the same as we have found out what is going on inside the steam cylinder by the use of the indicator.

In his paper Mr. Hague quotes Mr. Edwin Darling in his 1889 report of the Pawtucket, Rhode Island, Water Works, as follows: "No well conducted water works can afford to be without recording gauges, and, when properly located, they will, in my opinion, pay for themselves within one year" (*Proceedings Am. W. W. A.* Philadelphia, 1891, p. 77).

These extracts go to show that the value and usefulness of recording gages were fully recognized, more than twenty years ago. We certainly do need to know what is going on inside of the steam and water pipes under our charge, and at all times. A look at the non-recording gage shows us the pressure at that time, but is no proof or indication of what it was a minute before. The recording gage does give this information; it tells what the pressure was at any time, day or night, and on any date. It is a constant watchman, just as a water meter is a constant inspector. It keeps a complete and indisputable record of pressure at all times.

IN THE PUMPING STATION

A recording gage on the steam line is the best possible check on the work of the fireman and engineer. If pumping to a reservoir, under a constant load, the uniformity of the pressure line tells how uniformly the fires are being tended and the feed water applied. An absolutely even line would indicate perfection in the fire room, a ragged line, inattention on the part of the fireman. With properly kept boiler room records, the fireman's work can be accurately checked.

A sudden drop in the pressure line should correspond exactly with the record of fires cleaned or boilers blown off. A quick drop or sudden rise at any other time indicates improper firing.

With a direct pumping system, or where pressure has to be raised for fires, a less even steam line is to be expected; but a comparison of the steam and water charts will show how quickly the boiler responds to a sudden demand for more water pressure, by restoring and holding the pressure when the work of the pumping engine is suddenly increased. A direct pressure pumping system requires greater care and alertness on the part of the engineer and fireman, and the recording gages are the best possible means of knowing how well they perform their work. Perfection would mean a line equal to one drawn with a compass or straight edge, according to the style of chart used, and the nearest approach to this indicates the best work. A ragged, zigzag line means inattention and carelessness, or something wrong with the boilers, steam lines, engines or pumps. It rests with the chief engineer or superintendent to find out which is at fault, and to correct the fault; the gages cannot do this, they can only tell in positive language that something is wrong.

The presence of recording gages is an incentive and stimulus to the men to do better work. They know that they are constantly watched; that a constant and indisputable record is being made of their work. The superintendent, when he visits the pumping station, or when the gage chart is placed on his desk, has a perfect check on the work of the pumping plant force, and a record he can preserve for all time. When he has occasion to call an engineer or fireman to account for laxness, he has before him, to confront the culprit with, an undeniable record of his work. A poor pressure line may not be the fault of the engineer or fireman; it may be due to poor fuel, a leaky or sagging steam line, bad feed water, poor draft, or engine trouble; but the engineer is just as much at fault, for not promptly recording and reporting such troubles, as he would be for neglecting his work, or not keeping the fireman up to his part of it.

If good pressure charts are obtained for a while, but constantly and uniformly get bad, it indicates either that the plant is wearing out or being overloaded. If both good steam and water charts are obtained when the plant is pumping say 5,000,000 gallons a day, and grow more and more ragged as the pumpage is increased, they surely indicate that the pumps or boilers, or both, are being worked beyond their economic capacity. If the pressure lines grow in irregularity,

when there is no increase in the work, they indicate that some part of the plant is wearing out or is in bad order, and needs overhauling.

Steady lines of the steam charts indicate uniform and careful firing, and a steam plant in good condition. Ragged gage lines indicate either poor and irregular firing or bad condition of the boilers. If the feed water is a scale forming water, the poor gage lines bear out the evidence of the coal scales, that the boilers need cleaning.

A fireman cannot fill his firebox, then light his pipe and go out of the fire room to seek a cool place, and maintain an even line on his steam gage charts; but must stay by his fires, fire frequently and lightly, and keep clean fires. Knowing how completely he is on record he will be careful, and will also keep a record of everything that might affect his record, such as poor fuel, time of cleaning fires, blowing off boilers, etc. The latter records, which might otherwise be neglected, are in themselves of sufficient value to more than pay the cost of the recording gages, if no other benefits were obtained.

The vacuum gages should also be recording, to indicate the condition of the engines and pumps, a falling off in the height of the vacuum line indicating leaks that mean more coal. The lines on the vacuum gage charts should not vary much. If a vacuum of 27 can be obtained one month or year, it should be maintained the next month and year. If a higher vacuum is maintained with one kind of packing than with others, the one holding the high vacuum is the best, and probably the cheapest, though much higher priced than the others. The difference in cost might be made up many times in the saving of fuel.

No engine room is complete without at least three recording gages, as the operation of the plant cannot be properly checked and governed without them. They also insure better work on the part of the operatives.

Many times the recording gages create a spirit of rivalry between men on different shifts, through an effort on the part of each shift to do better than the others, to show more even lines on the charts; thus causing all to do better and more economical work.

There should be a certain economical relation between the steam pressure and the water pressure. When this is worked out it should be as closely maintained as possible. An unnecessarily high steam pressure, even though it gives a very uniform gage line, is not economical.

ON THE DISTRIBUTION SYSTEM

On gravity supplies or pumping plants, in cities of considerable size, a gage, or gages, should be placed on the distribution mains at some central point, or at typical points. If more than one service, high and low service, each should have a recording gage. It is well, when practicable, to take gage services off of large or leading mains, where they will not be liable to the great fluctuations in pressure frequent on smaller distribution pipes.

Of course there should be a gage in the office, where it will be under the eye of the superintendent when in the office, and, at other times, of some other officer or employe of the water works, of the night watchman, if one is employed; one in the superintendent's house, for reference at night, is convenient, but, with telephone connections, not so necessary.

The connection to the gage should be entirely independent of all other service to the building in which it is located. It should be of good size, not less than $\frac{3}{4}$ inch, and placed where it will be in no danger of freezing, as there cannot be a circulation in the gage service and an accurate record of pressure on the main at the same time, without the expense of a double service, in which a free circulation would be doubtful, unless it were very carefully planned, and even then there would be an item of friction in the smaller pipe, that would be difficult to account for. Of course water cannot be allowed to run in the gage supply pipe, in cold weather, without totally destroying the value of the gage record.

The gage service should be so arranged as to be easily blown out or flushed, to avoid all possibility of stoppage, by an accumulation of sediment. While a $\frac{3}{4}$ inch or larger service is recommended, the gage operates with a very small opening; the object of the large service is to avoid stoppage.

LOCATION OF GAGES

The pumping station gage comes first, and, in smaller plants, is all that is required. Larger plants should also have an office recording gage. Cities or towns with two or more services should have a record on each service. Large cities should have recording gages at various points on the distribution system, notably near the congested value districts.

Gages can be placed in the residences of employes of the works.

They require little attention, winding of clock, changing of charts, and seeing that the pen, where ink records are made, is kept properly filled.

The fire department stations are convenient places for recording gages, and the fireman's interest in the water pressure is enough to insure proper attention. For municipal plants, police stations can be utilized, if they are better located than the fire engine houses, that is, on larger supply mains.

Very long services should, naturally, be avoided, both on account of the expense and the danger of stoppage in long lines of small pipes. The service should be of durable material, and, with corrosive waters, iron services should be avoided, as an accumulation of iron rust would stop up the minute orifice of the gage.

THE BENEFITS OF RECORDING GAGES

The benefits of recording gages are many; they have been known to stop law suits, where actions for damages caused by low pressure were threatened. The recording gage settles many disputes concerning pressure at time of fires or other times. Often complaints of low pressure are made, not enough to supply the upper floors of some buildings. A nearby recording gage demonstrates that it is a local trouble, within the building. These complaints are frequently that the pressure is low at certain hours of the day or night, but a gage chart showing a uniform pressure at those hours, demonstrates that it is local use of water, in the building itself, or in the distribution system near it, that causes the trouble.

The recording gage charts show the effect of cold weather on the water supply, the low pressure lines on the chart in freezing weather indicate the extent to which water is being run to prevent freezing. They also reflect the hot weather use of water; a low pressure line on the chart at night tells of water allowed to run on lawns all night.

PORTABLE RECORDING GAGES

All parts of a city cannot at all times be covered by recording gages, so that the story they have to tell is incomplete. Portable recording gages set up in various places for short periods make a fairly complete record of the conditions of the supply at points on the distribution not covered by regularly established recording gages. Such records in large buildings, factories, etc., where the fire hazard is great, are particularly useful.

A gage set up for a single day gives a valuable record, as it shows a comparison between the day and night pressure at some particular point.

Portable gages can, with advantage, be connected to fire services, as, on such services, they would be free from the fluctuations due to the use of water on the premises, or, if the fluctuations existed, they would reveal improper use of water from the fire services. With a small portable house or box to protect them, gages can, in warm weather, be attached to fire hydrants, to make a record of the pressures on the mains at any point. Summer records of this kind, made on the outlying mains, mains in sparsely built up parts of the city, on long runs of small distribution pipes, and on the outskirts of the town, are of great value and interest.

PRESERVATION OF GAGE CHARTS

Charts should be permanently kept as a part of the records of the works; as part of the history of the plant. They should be conveniently filed for reference at any time. For straight line charts suitable albums or scrap books make a convenient file. For round charts the scrap book form, though suitable and convenient, is bulky, as a page would be required for each day's chart. Substantial pasteboard boxes of the right size to hold a year's charts, are convenient. These can be labelled with the year, and, where several recording gages are in use, with the location of the gage, making it convenient to refer to the charts from any gage at any time.

It is interesting to look over the old gage charts, also often instructive. A new water works, with new and clean pipes, with pumps not over crowded, and ample size force and distribution mains should show a steady line, with slight fluctuations, and near the outer edge of the chart. As the consumption increases, the line grows less and less steady, and converges toward the center of the chart, showing the reduced pressure due to greater friction in the mains. The raggedness of the pressure line on the chart also increases with the age of the plant, as the mains become tuberculated and clogged with sediment. Finally, the consumption has gone beyond the pump capacity; a new and larger pump is installed, and the pressure line again approaches the outer edge of the chart, and becomes more steady, but still shows greater fluctuation than when the plant was new and working at a comfortable rate.

Notwithstanding the new pumping engine, the results are not entirely satisfactory, when compared with the earlier charts; the pumping engine, though of ample capacity, is working harder than the original pump had to work; both the water and steam pressure lines on the pumping station gages have approached nearer to the outside circles. Higher water pressure has to be maintained on the pumps to keep up the pressure on the distribution mains. A comparison of the gage charts from year to year shows this steady gradual increase of the pumping station pressures, and, at the same time, lessening of the pressure at the office and other points on the distribution system. Finally, the pumps are unable to give a proper pressure in the town, though they have a capacity even greater than the demand. A new force main is installed, and the original conditions are nearly restored, though the pressure lines are not quite as steady as at first, owing to bad condition of the pipe system. A thorough cleaning of the mains and distribution pipes restores the steady pressure line near the outer edge of the circle. So, the gage chart tells us when a new pumping engine is needed, when to install a larger force main and feed mains, when the mains need cleaning.

A study of the old gage charts tells a story, relates a plant history, as old documents or old letter files tell the story of the community. This is especially so if the charts are carefully and properly labelled before they are filed away; the date, the temperature and weather conditions, notes concerning fires, breaks in mains, engine or steam plant troubles, etc.

A frequent examination of the files of old charts should be made, as they tell an interesting and valuable story of the operation of the works, and give valuable hints for needed changes and improvements.

There is now an instrument for ascertaining from the pressure lines on circular charts, the style now mostly used, the average daily or weekly pressures. These results can be conveniently plotted, so as to show compactly the average pressures throughout a year, or many years. The plotting of two or more years on the same sheet, using different colored inks for the different years shows compactly the comparative pressures for the equal seasons of each year. Temperature and weather condition notations, would add to the interest of these charts. For instance, the month of February in one year shows a steady and good pressure line, while the same month of the next year shows low pressure and a ragged line. The temperature reference shows for one year a moderate temperature, for the other

steady cold weather with extremely low temperatures. Without the temperature record the great difference in pressure would be hard to explain.

Consumption records should also be included, to account for the probable steady decrease in average pressures from year to year. Like the February temperature record, the mid summer temperature and precipitation records would also tell their story.

Recording gages are useful in so many ways, give so much information and so good a record of the daily operation of the pumping plant and the condition of the plant, that they are indispensable, and no well regulated water works should be without them, and none can have too many. A superintendent cannot have accurate knowledge of the operation and condition of the plant under his supervision without using pressure recording gages. It is false economy to try to do without them. The cost of installation and maintenance is small, trifling, as compared with the benefits.

Pressure recording gages require little care, if daily charts are used, and they give the best records—daily changing of the charts, winding the clock, and filling the pen, are all that is necessary. The supply pipe should be blown out occasionally, to keep it clean, and the clock kept regulated, so that the time records will be accurate. This last item is important, should disputes arise, concerning pressures at time of fires, particularly in towns where an increased fire pressure is required. The rise of the pressure line in the chart should correspond to the instant with the record of the fire alarm. In this connection, some care must be exercised in placing the charts, to see that they start on the correct time line. Some troubles have been caused by carelessness in this, occasionally, for some unapparent reason, the gage chart does not revolve, though the clock is going. This may be due to careless securing of the chart, or to putting in two charts at once, the under one revolving all right, but not receiving the impression of the pen or pencil, the outer one slipping on the smooth surface of the lower one and remaining stationary.